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SOME OBSERVATIONS ON THE FOOD OF THE HERRING.

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(Reprinted from the *Twenty-fifth Annual Report of the Fishery Board for Scotland, Year 1906.—Part III.*)



GLASGOW:
PRINTED BY JAMES HEDDERWICK & SONS LIMITED,
AT THE "CITIZEN" PRESS, ST. VINCENT PLACE.

VI.—SOME OBSERVATIONS ON THE FOOD OF THE HERRING.

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The organisms which constitute the food of the herring—their various kinds, their distribution, and their influence on the movements of the fish—have for a long time engaged the attention of students of marine natural history, and it is now many years since the Fishery Board for Scotland commenced investigations into the nature of the food of the herring and of various other problems connected with the herring fisheries of Scotland.

In 1885 an important paper on the food of the herring was contributed to the Fourth Annual Report of the Fishery Board for Scotland by the late George Brook, F.L.S., in collaboration with Mr W. L. Calderwood, the present Inspector of Salmon Fisheries for Scotland. In this paper the results of the examination of between fourteen and fifteen hundred stomachs of herring containing food are given in detail in a Table which fills eighteen pages of the Report.

The stomachs had been received from various places all round Scotland, including the district of Berwick-on-Tweed, the Firths of Forth and Tay, Aberdeen, the Moray Firth District, Loch Broom, West Ross-shire, and the Firth of Clyde, including Loch Fyne. All these stomachs were such as contained food that could in most cases be identified. Many other stomachs had been examined, but as they proved to be empty or the food they contained was so disintegrated by the digestive fluids as to be undistinguishable, they were by the authors excluded from the paper in question.

The observations which follow, and which may be considered as supplementary to the paper by Brook and Calderwood, describe the results obtained from the examination of fully five hundred herrings' stomachs, selected from various fishing centres in Scotland. The Table appended contains a summarised statement of the number of stomachs and of the dates when they were examined, and also of the localities from whence they were sent.*

TABLE I.

| Dates when the stomachs were examined. | Number of stomachs examined. | Localities whence the fish were sent. |
|--|------------------------------|---|
| December 1904 | 17 | Loch Fyne. |
| February 1905 | 55 | Loch Fyne, Loch Broom. |
| June , | 122 | Campbeltown, Loch Broom, Stornoway, Anstruther. |
| July , | 93 | Loch Fyne, Campbeltown, Stornoway. |
| August , | 19 | Kilbrennan Sound (Pirnmill). |
| September , | 33 | Loch Fyne, Carradale. |
| December , | 38 | Loch Fyne. |
| January 1906 | 31 | Campbeltown. |
| September , | 11 | Loch Fyne. |
| October , | 11 | Loch Fyne. |
| November , | 12 | Loch Fyne, Shetland, Wick, Peterhead. |
| December , | 11 | Loch Fyne, Girvan, Rothesay. |
| January 1907 | 17 | Clyde, Stornoway. |
| February , | 19 | Campbeltown, Rothesay, Stornoway. |
| March , | 22 | Campbeltown, Skipness, Stornoway. |
| April , | 5 | Skipness, Machrie Bay (Arran). |

* I desire to acknowledge the assistance I have received in this inquiry from my colleague, Dr. H. C. Williamson.

Rather more than half the number of stomachs examined were found to be empty or the food they contained could not be satisfactorily determined; fully forty-five per cent. of them were the stomachs of female fish, and fifty-two per cent. males; a few had their reproductive organs so immature that it was considered doubtful whether they were milters or spawners. Those found to contain food that could be identified numbered two hundred and forty-three. Of these stomachs about fifty-two and a half per cent. were those of female fishes, two were doubtful, and the others those of male fishes, as shown in the subjoined Table.

TABLE II.

TABLE showing the proportion of stomachs containing food and those containing no food that could be identified, the proportion of males to females, and the names of the districts from which they were sent.

| Names of the Districts. | Stomachs containing Food. | | | Stomachs containing No Food. | | | Totals of ♀ and ♂ and ? | | | Total Number of the Stomachs Examined. |
|----------------------------|---------------------------|-----|---|------------------------------|-----|---|-------------------------|-----|---|--|
| | ♀ | ♂ | ? | ♀ | ♂ | ? | ♀ | ♂ | ? | |
| Loch Fyne | 42 | 36 | 1 | 26 | 32 | 0 | 68 | 68 | 1 | 137 Stomachs |
| Clyde | 42 | 41 | 1 | 41 | 48 | 4 | 83 | 89 | 5 | 177 ,, |
| Loch Broom | 0 | 0 | 0 | 40 | 35 | 0 | 40 | 35 | 0 | 75 ,, |
| Stornoway | 27 | 24 | 0 | 2 | 6 | 0 | 29 | 30 | 0 | 59 ,, |
| Anstruther | 8 | 13 | 0 | 15 | 20 | 0 | 23 | 33 | 0 | 56 ,, |
| Peterhead, Wick, Shetland. | 8 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 8 ,, |
| | 127 | 114 | 2 | 124 | 141 | 4 | 251 | 255 | 6 | |
| Totals | 243 | | | 269 | | | 512 | | | 512 ,, |

Description of the Food observed in the Stomachs of Herrings sent from Loch Fyne, the Firth of Clyde, Loch Broom, Stornoway, Anstruther, and other places.

In describing the food observed in these herrings' stomachs, the various samples from the same place or district are arranged together under the name of the district and according to the date on which they were examined, and for convenient reference the names of the districts arranged as in Table II.

(1) LOCH FYNE HERRINGS.

December, 1904.—The stomachs of seventeen herrings sent from Loch Fyne were examined at this date. They all contained some food, but it was so disintegrated by the digestive fluids that only in three examples could the nature of it be determined, and even in these to a limited extent. The food in these three stomachs appeared to consist exclusively of Schizopods belonging to the Euphausiidæ. Neither the species or genus could be satisfactorily determined, but probably they were all young *Nyctiphantes, norvegica* as that species is common in Loch Fyne.

February, 1905.—The stomachs of six herrings from a sample sent from Loch Fyne contained each a considerable amount of *Calanus helgolandicus*.

July, 1905.—No more herrings from the Loch Fyne district were submitted for examination till July, when the stomachs of twenty-three specimens were examined. These form part of a sample captured about the end of April and retained during the interval in a cold storage chamber. All the stomachs contained food, and in most of them the quantity observed was considerable, and with two exceptions consisted entirely of Copepoda—*Calanus helgolandicus* being apparently the only species represented. In the two exceptions referred to the food consisted of post-larval fishes and *Calanus*, and my notes indicate that the food in these two was more decomposed than in the others, due probably to the presence of the young fishes.

September 22nd, 1905.—The stomachs of eight herrings were examined. They were from a sample sent from Strachur, and captured two days previously. Two of them were considerably distended, but contained no food; three contained some red-coloured matter, but there was nothing that could be identified; one was packed full with *Calanus*; in the other two there was some red-coloured stuff with fragments of Copepods mixed up with it.

December 11th, 1905.—The stomachs of thirty-four herrings sent from Loch Fyne were examined. Sixteen were found to be empty, or contained some red-coloured matter probably derived from *Calanus*, but no trace, even of their appendages, could be detected. All the others contained the remains of *Calanus*, the specimens being in a number of cases tolerably whole, in others they were more or less fragmentary. There was also present in many of the stomachs a quantity of red-coloured oily matter derived probably from the *Calanus*. The fish whose stomachs contained food comprised 6 ♀ and 12 ♂, and the others 7 ♀ and 6 ♂.

January, 1906.—The stomachs of twenty herrings sent from Strachur were, with one exception, found to contain food, which appeared to consist entirely of *Calanus*. Some of the stomachs contained a considerable quantity of food. The fishes comprised 11 ♀ and 8 ♂. The empty stomach belonged to a male fish.

September 8th, 1906.—Eleven stomachs from Loch Fyne herrings were examined at this date. One contained some food too much digested for identification. One contained *Calanus*, *Centropages hamatus*, *Metridia lucens*, and young Euphausiidæ. One contained *Calanus*, *Centropages hamatus*, *Evadne nordmannii*, and some Decapod larvæ, and another contained a small quantity of *Calanus* only. The food observed in five of the others consisted entirely of *Nyctiphantes norvegica*, while two contained the remains of Euphausiidæ which probably also belonged to *Nyctiphantes*, but they were too much digested to be satisfactorily determined.

October 12th, 1906.—The eleven stomachs of Loch Fyne herrings examined at this date all contained food, in most cases in considerable quantity. The sexes represented comprised 9 ♀ and 2 ♂. The food observed in two stomachs consisted chiefly of *Calanus*, but *Centropages hamatus*, *Temora longicornis*, *Oithona similis*, and Decapod larvæ were also present. A small quantity of food, apparently all *Calanus*, was observed in another. A third contained a moderate quantity of *Calanus*, but *Temora longicornis* was also present. The food observed in other four appeared to consist entirely of Euphausiidæ, and were probably all *Nyctiphantes*—at least this was the only species that could be identified.

One contained *Calanus*, *Metridia lucens*, another a small number of Decapod larvæ, while one contained the remains of a considerable number of Euphausiidæ (*Nyctiphantes* probably), and a few post-larval fishes which appeared to be sand-eels.

November 9th, 1906.—The stomachs of four herrings from Loch Fyne examined at this date contained a considerable quantity of food which appeared to consist entirely of *Calanus*. The fishes comprised 2 ♀ and 2 ♂.

December 18th, 1906.—A small sample consisting of the stomachs of three Loch Fyne herrings (2 ♀ and 1 ♂) contained a small quantity of food of a semi-fluid nature, but no trace of anything that could be identified.

(2). THE CLYDE.

June 2nd, 1905.—Examined the stomachs of twenty-seven herring sent from Campbeltown. One contained one or two fish scales, another was filled with *Nyctiphantes*, and two contained some red-coloured matter with fragments of *Calanus* mixed up with it; the others were either empty or contained nothing that could be identified.

July 3rd, 1905.—Examined the stomachs of thirty-six herrings also from Campbeltown, but only five of them contained food that could be determined even in a limited degree. These fishes had been captured on 11th March, and kept in a cold storage chamber. In one the food consisted of Annelids (Chætopoda) and Amphipoda (Hyperiidæ), while the other four contained the remains of Crustacea, apparently belonging to *Calanus*.

August 9th, 1905.—The stomachs of nineteen herrings from Pirnmill, Kibbrennan Sound, were examined at this date, but captured on the 26th of the preceding month. Seven were empty or did not contain anything that could be identified. Ten contained food which appeared to consist entirely of Schizopods (Euphausiidæ), probably all *Nyctiphantes norvegica*,—at least those specimens that could be satisfactorily distinguished belonged to that species. In one which contained only a small quantity of Crustacean remains, the only species identified was *Centropages hamatus*, while another contained Crustacean remains that could not be determined with certainty.

September 2nd, 1905.—Twenty-five stomachs of herrings from Carradale were examined, but they had been captured on July 26th. They were all empty, and many of them were distended with air. The fishes comprised 14 ♀ and 11 ♂. In several cases the stomachs were covered externally with white clean fat.

January 21st, 1906.—Eleven stomachs of herrings from Campbeltown contained food that consisted chiefly of *Nyctiphantes norvegica*, some *Calanus* being also present. Most of the stomachs were full, and some were considerably distended by the large quantity of food they contained. Five of the herrings were females and six males.

December, 1906.—No further stomachs of herrings from the Clyde were submitted for examination till December, when four from a sample sent from Girvan and the same number from a sample from Rothesay were examined. Those from Girvan all contained food that could be identified. One contained a moderate quantity of food which appeared to consist entirely of *Calanus* in a fragmentary condition. One contained Euphausiidæ very much digested, while the food observed in the other two consisted of Euphausiidæ and *Calanus*.

Three of those from Rothesay contained only a small quantity of food, which consisted entirely of *Calanus*, and the other was well filled with

apparently the same organisms, but too much decomposed to be satisfactorily identified.

January, 1907.—The stomachs of fifteen herrings from the Clyde were examined; they comprised small samples from two or three different places. Five sent from Rothesay contained food that appeared to consist entirely of young Euphausiidæ, some of which that could be identified, and probably the others also, belonged to *Nyctiphanes norvegica*. The food observed in other six stomachs consisted of *Calanus* only, of which there were a considerable quantity. In other three the food consisted of *Calanus* (chiefly), *Sagitta* and young Euphausiidæ, and one was distended with food consisting chiefly of *Nyctiphanes*, but some *Calanus* were also present.

February, 1907.—The number of stomachs from Clyde herrings examined in February was thirteen. Eight were from two samples sent from Campbeltown, and five from a sample from Rothesay. Four of the stomachs from Campbeltown herrings contained food that consisted entirely of *Calanus*. One contained a large quantity of *Nyctiphanes*, while the food observed in the other three consisted of *Calanus* and *Nyctiphanes*. The stomachs of the five herrings from Rothesay differed much from those from Campbeltown; two were empty, two contained a small quantity of red-coloured matter, but nothing that could be distinguished, while the only thing distinguishable in the other consisted of a few fish scales.

March, 1907.—The stomachs of eighteen herrings from the Clyde were examined in March; they included eleven from Campbeltown, four from Skipness, and three from Girvan. All the stomachs of the Campbeltown herrings contained food that could be identified. In four the food appeared to consist entirely of *Calanus*; other organisms may have been present, but the food had become so much decomposed that only the *Calanus* could be satisfactorily identified. The food in one stomach consisted entirely of young Euphausiidæ, while the contents of the other six comprised *Calanus* and Euphausiidæ in varying proportions. In three cases the Euphausiidæ present in these stomachs were certainly *Nyctiphanes norvegica*, and probably all those observed belonged to the same species. Of the four stomachs from Skipness herrings two were empty; one contained a small quantity of food, but it was too much decomposed for identification, while the other which was tolerably well filled contained Euphausiidæ and *Calanus* in a partially digested condition. The contents of one of the stomachs of the Girvan herring consisted of *Calanus*, *Pseudocalanus elongatus*, young Euphausiidæ, and some fish eggs. This stomach was moderately well filled with food, but the other two were empty.

April, 1907.—The stomachs of a few herrings from Skipness and Machrie Bay (Kilbrennan Sound) were examined—two from the former and three from the latter place. Those from the Skipness herring contained so much food as to be somewhat distended with it; one was filled for the most part with *Calanus*, but three moderately large *Nyctiphanes* were also present; the other contained *Nyctiphanes* and *Calanus* in about equal quantities. On the other hand, the stomachs of the herrings from Machrie Bay, though at first sight apparently containing a moderate amount of food, were found on examination to consist only of some red-coloured stuff that could not be identified, though probably it was part of the remains of some *Calanus*.

(3) LOCH BROOM.

February 1st and 2nd, 1905. The stomachs of forty-nine herrings captured in Loch Broom, West Ross-shire, were examined in February,

1905 ; a considerable proportion of them were entirely empty, a number of the others contained some red-coloured fluid, probably derived from organisms captured by the fishes, but there was nothing that could be identified. In several instances the stomachs were distended with air, the result perhaps of fermentation. The fishes represented by these stomachs comprised 29 ♀ and 20 ♂.

June 1st, 1905.—Thirty-six stomachs of herrings sent from Loch Broom were examined at this date. The results obtained resembled generally those of the previous sample. A number of the stomachs were found to be entirely empty, and the others contained some semi-fluid matter usually of a reddish colour, but no trace of anything that could be identified with certainty. In some cases, as in the previous sample, the stomachs were considerably distended with air.

(4) STORNOWAY.

June, 1905.—The stomachs of thirteen herrings, being part of a sample sent from Stornoway on May 19, were examined in June. They all contained food which, with one exception, consisted for the most part of post-larval fishes. In the one stomach referred to, however, no fishes were observed, but the food consisted entirely of Decapod larvæ, of which there were a considerable quantity. Eight stomachs contained fishes only, while the others contained both fishes and crustacean larvæ. The fishes appeared to be mostly sand-eels, but Clupeoids may, in some cases, have also been present; the food, however, had already undergone digestion to some extent, and the species could not in a few examples be satisfactorily determined. One stomach at least was crammed full with post-larval sand-eels, and two others were fairly well filled with the same kind of fish. The only other organism observed in addition to the Decapod and fish larvæ was a single specimen of *Caligus rapax*. All the thirteen herrings were females with undeveloped ovaries.

July 7th, 1905.—The stomachs of thirty-four herrings sent from Stornoway were examined. Eight of them were either empty or contained a small quantity of semi-fluid matter, but nothing that could be identified. The other twenty-six contained food which consisted for the most part of post-larval fishes, chiefly sand-eels. In only two examples were fish remains apparently absent, and the food in one of these consisted of the remains of Calanoida and in the other of Euphausiidæ, but these organisms were so much disintegrated that the species could not be satisfactorily determined.

Eight stomachs were distended with the large quantity of young fishes they contained, while as many more were tolerably well filled with them. In a few cases *Calanus* were found in the same stomachs with the fishes. Seven of the thirty-four herrings were spawners, but there was no indication that difference in sex resulted in any difference in the nature or quantity of the food consumed.

January 17th, 1907.—The stomachs of two herrings (♀ and ♂)—part of a sample from Stornoway—contained each a small quantity of food consisting of fragments of Schizopods (Euphausiidæ); they were so disintegrated as to be almost indistinguishable, but the only fragments that could be identified with certainty belonged to *Nyctiphantes*.

February 14th, 1907.—Six herrings (5 ♀ and 1 ♂), from another sample sent from Stornoway, had all of them food in their stomachs. Two were tolerably full, but the quantity in the others was small. One contained post-larval fishes—apparently Clupeoids, but the food observed in the others consisted only of *Nyctiphantes*.

March 16th, 1907. The stomachs of four herrings (3 ♂ and 1 ♀), part of a sample also from Stornoway, contained each a fair quantity of food. In one, which was tolerably well filled, the food consisted partly of *Nyctiphantes* and partly of Hyperiidæ (*Parathemisto*), but in the other three it consisted of *Nyctiphantes* only.

(5) ANSTRUTHER, FIRTH OF FORTH.

June 6th, 1905.—The stomachs of fifteen herrings from a sample sent from Anstruther were examined for food; with one exception, they were all male fishes. Only three of the stomachs contained food; all the others were empty. The food observed consisted entirely of *Parathemisto obliqua*. One of the stomachs containing *Parathemisto* was that of a female fish.

June 10th, 1905.—Twenty-five stomachs from another sample of herrings sent from Anstruther were examined. Eleven were found to be empty, and of the others one contained the remains of crustacea—probably fragments of *Parathemisto*—but they could not be satisfactorily determined. The food observed in five of the others appeared to consist entirely of the species of Amphipod just referred to, while that contained in the other eight stomachs included both *Parathemisto* and Euphausiidæ. These Schizopods, though they could not be identified with absolute certainty, appeared to belong to *Thysanoessa* sp. Four of the stomachs (two from female and two from male fishes) were distended with the large amount of food they contained, and which consisted of Amphipods and Schizopods in about equal proportions.

(6) PETERHEAD, WICK, AND SHETLAND.

November, 1906.—The stomachs of a few herrings representing samples sent from Peterhead, Wick, and Shetland, were examined in November. Two, which were those of fishes belonging to a sample from Peterhead, contained each a tolerable amount of food. In the one case it consisted for the most part of the Decapod larvæ and in the other of *Calanus helgolandicus*.

Three stomachs of herrings from a sample sent from Wick were also found to be well supplied with food. In two of them the food appeared to consist entirely of *Metridia lucens*, and in the other of young fishes which were too much decomposed to be satisfactorily identified.

The remaining three stomachs were those of herrings from a sample sent from Shetland. Like the others, they each contained a considerable amount of food, but in this case it consisted entirely of Euphausiidæ, but it was not in a condition to permit of an exact determination. From a careful examination of the fragments, however, I think it highly probable that they belong to the genus *Thysanoessa*.

I now append in tabular form the names of the various organisms referred to in the preceding notes.

TABLE III.

List of organisms observed in the preceding notes with the localities where the herrings were sent from.

| Names of the Organisms. | Loch Fyne. | Clyde. | Loch Broom | Stornoway. | Anstruther. | Peterhead. | Wick. | Shetland. |
|----------------------------------|------------|--------|------------|------------|-------------|------------|-------|-----------|
| Post-larval fishes—Clupeoids (?) | + | ... | | x? | ... | ... | +? | ... |
| „ „ Sand-eels - | +? | ... | | ++ | ... | ... | ... | ... |
| Fish eggs | ... | + | | ... | ... | ... | ... | ... |
| Fish scales | ... | + | | ... | ... | ... | ... | ... |
| Nyctiphantes norvegica | ++ | ++ | | + | ... | ... | ... | ... |
| ? Thysanoessa, sp. | ... | ... | | ... | + | ... | ... | ++ |
| Euphausiidæ | ++ | ++ | | ++ | ++ | ... | ... | ... |
| Hyperia galba? | ... | + | | ... | ... | ... | ... | ... |
| Parathemisto obliqua | ... | ... | | + | ++ | ... | ... | ... |
| Evadne Nordmanni | + | ... | | ... | ... | ... | ... | ... |
| Calanus helgolandicus | ++ | ++ | | + | ... | ++ | ... | ... |
| Pseudocalanus elongatus | ... | ++ | | ... | ... | ... | ... | ... |
| Centropages hamatus | + | + | | ... | ... | ... | ... | ... |
| Temora longicornis | + | ... | | ... | ... | ... | ... | ... |
| Metridia lucens | + | ... | | ... | ... | ... | ++ | ... |
| Oithona similis | + | ... | | ... | ... | ... | ... | ... |
| Caligus rapax | ... | ... | | + | ... | ... | ... | ... |
| Decapod larvæ | + | ... | | ++ | ... | ++ | ... | ... |
| Annelida—Chætopoda | ... | + | | ... | ... | ... | ... | ... |
| „ Sagitta - | ... | ++ | | ... | ... | ... | ... | ... |

The only food observed in stomachs from
Loch Broom was some red-coloured
matter, probably derived from *Calanus*.

NOTE—The sign + indicates that the organism was generally not very plentiful in any stomach examined. ++ indicates that the organism occurred in at least some of the stomachs in considerable quantity.

It will be observed from this Table and from that in Brook and Calderwood's paper in the *Fourth Annual Report of the Fishery Board for Scotland*, that the food of herring captured off the coasts of Scotland consists mainly of four or perhaps five groups of organisms, viz., (1st) Post-larval fishes, (2nd) Amphipoda, (3rd) Copepoda, (4th) Schizopoda, and (5) Decapod larvæ, and a few remarks on each of these groups may not be out of place here.

1st—Post-larval fishes. The post-larval fishes most frequently mentioned by Brook and Calderwood are Clupeoids—chiefly young herrings and sprats. Sand-eels are only recorded eleven times, from places all on the East Coast, and were from herring taken at various times during the year, from January to August. They occurred usually in quantity. In the stomachs examined for this paper, sand-eels in quantity were only observed in herrings from Stornoway, and a few doubtful examples were noticed in Loch Fyne herrings. Clupeoids were seldom observed in the fishes examined for this paper.

2nd—Amphipoda. The only species of Amphipoda that appear to be of much importance as herring food belong to the Hyperiidæ, and those that have been most frequently recorded are *Hyperia galba* and *Parathemisto obliqua*. The first is the form commonly mentioned by Brook and Calderwood, but it has been rarely met with in the stomachs examined for this paper. Hyperiidæ have been met with in the stomachs of herrings chiefly from the East Coast and during the first three and the last months of the year, but they have also been occasionally observed in June and July. The authors referred to above do not appear to have obtained them in the stomachs of any herrings from the West Coast. They occurred, however, in March in three stomachs of

herrings sent from Stornaway, which is a West Coast station (see notes under Stornoway). It is an interesting question why the Hyperiidæ should so frequently occur in the stomachs of East Coast herrings and so sparingly in those from the West Coast.

3rd—The Copepoda. The most important of the Copepod species as herring food is undoubtedly *Calanus*. It will be observed that the name given in my list to this form is *Calanus helgolandicus*, Claus, but after all it may only be a smaller form of *Calanus finmarchicus*, Gunner, for, with the exception of size, the differences between them is not very marked, and a familiarity with the two forms is necessary to enable one to separate them—but this is a question that need not be discussed here.

Calanus is usually observed in greater quantity in stomachs of West Coast herrings, and especially of those from the Clyde and Loch Fyne, than in those from East Coast fishes, and it is noteworthy that the species, though common enough in the Firth of Forth, appears to form a very small portion of the food of herrings captured in that estuary. In Brook and Calderwood's paper Copepoda are recorded on only two occasions from herrings sent from the Firth of Forth, and they were not observed at all in the stomachs of the herrings sent from Anstruther and examined for this paper. *Calanus* has been obtained in the stomachs of Loch Fyne and Clyde herrings, frequently in considerable quantity, from April till November, in those from Stornoway in May and June, and in those from Shetland in April. Other species of Copepoda are sometimes observed in the stomachs of herrings, i.e. *Centropages hamatus* and *typicus*, *Temora longicornis*, *Metridia lucens*, *Pseudocalanus elongatus*, *Acartia* sp. and *Oithona similis*, but seldom in any quantity, and are only of interest as bearing on the extensive bill of fare from which the herring may select its food.

4th—Schizopoda. All the Schizopoda found in the stomachs of herrings caught off the Scottish coasts are, with few exceptions, members of the family Euphausiidæ, and belong to one or other of the three genera *Nyctiphanes*, *Rhoda* (better known perhaps as *Boreophausia*) and *Thysanoessa*. On the other hand, Schizopoda belonging to the family Mysidæ such as *Schistomysis spiritus*, Norman, and *Macromysis flexuosa* (O. F. Müller), which at times are met with in swarms, and other species of less frequent occurrence as *Leptomysis gracilis*, *Gastrosaccus spinifer*, but which are also widely diffused in our coastal waters, are rarely observed amongst the food of herrings. The only Schizopod mentioned by Brook and Calderwood, other than species belonging to the Euphausiidæ, is a *Siriella*, and it is recorded from the stomach of a herring from Tarbert, Lower Loch Fyne. One notable characteristic of the Euphausiidæ is that they all possess phosphorescent organs, which appear to be entirely wanting in the Mysidæ. This power of becoming luminous which the Euphausiidæ possess may explain to some extent why they receive so much attention from the fish, while the others are as seldom found in their stomachs.

The Euphausiidæ may be considered as equal to or even of greater importance than the Calanoida as a food supply for herring both on the East and West Coasts. Moreover, they have been observed in the stomachs of herrings more or less all through the year from January to December, though they appear to be more commonly met with during the earlier and later months of the year.

The Schizopod most in evidence, and most frequently recorded as herring food, is *Nyctiphanes norvegica* (M. Sars), while *Thysanoessa* and *Rhoda* are only occasionally mentioned; these two forms may, however,

occur more frequently than the records of them would seem to indicate, for it is quite possible they may sometimes be included under the more general name of Euphausiidæ. The use of this less definite name is often rendered necessary owing to the disintegrated condition of the food, which, though perfect enough to show the relationship of the organisms composing it with the family referred to, are too incomplete to permit of the satisfactory identification of the species or even of the genus to which they belong.

5th—Decapod larvæ. In the observations on the food of herrings given under each district, it will be observed that Decapod larvæ, though they may occasionally be found in considerable numbers in a few of the stomachs examined, they do not appear to hold a very important place in the herrings' bill of fare. Of the stomachs containing food examined for this paper, Decapod larvæ were observed in scarcely $3\frac{1}{2}$ per cent. of them, and the percentage of records for these larval forms in Brook and Calderwood's paper was even less. This infrequency of their occurrence in the stomachs of herrings, as compared with *Calanus*, can hardly be ascribed to the rarity of these organisms, for at times they are present in the sea in considerable numbers, as shown in plankton gatherings. It has to be remembered, however, that many of these larvæ are provided with a tough carapace and a spiny armature of a somewhat formidable character, which may tend to make herrings reluctant to attack them if other food of a more harmless kind be within reach.

Some other forms, *i.e.*, *Pseudocalanus*, *Centropages*, *Temora*, &c., among the Copepoda, *Evdne*, as representing the Cladocera, *Sagitta*, and other Annelida, and the eggs and scales of fishes have also been recorded, but they occur so very sparingly as to suggest that their presence with the other organisms in the stomachs may be due to their having been accidentally captured by the fish while in pursuit of other species.

In dealing with a subject like this, it sometimes happens that a question emerges which, though not bearing directly upon it, is yet of interest because of its negative character. In studying the food of herring it soon becomes evident that *Calanus*, for some reason, forms an important part of it, and one likely reason, though it may not be the only one, is that this Copepod abounds everywhere throughout the wide area where herring fisheries are carried on. It has also been shown that the herring does not gather its food from the water merely by using its gills as a kind of sieve, but hunts for and captures the organisms it lives on, and this seems to indicate that the fish may be able to some extent to discriminate between forms it prefers and those it dislikes. But though it may be able to do so, it is doubtful if it can distinguish differences that separate closely-allied species, as, for example, between *Calanus* and *Pseudocalanus*, or between that species and *Temora* or *Metridia*, except that the *Calanus* is larger than the others. It is not surprising, therefore, to find that while the herring apparently prefers *Calanus*, other species should occasionally be present amongst its food, especially if they are moderately common. Keeping this in view, it is interesting to note that in the published accounts relating to the food of Clyde and Loch Fyne herrings there is not, so far as I know, a single record of *Euchaeta norvegica* having been observed amongst the food contained in their stomachs. This *Euchaeta* is now known to be generally common and at times abundant in Loch Fyne and it is moderately frequent in other portions of the Clyde area, but in none of the samples of Clyde herrings submitted for examination has *Euchaeta* been observed as part of their food. No doubt this Calanoid appears to be a true deep-water form, but it is also occasionally obtained amongst plankton collected

comparatively near the surface of the water, and thus comes quite within the reach of the herrings. It is a large species, much more so than *Calanus*, but not too large for herring to swallow, seeing that the Euphausiidae are so frequently captured by them. The *Euchætae* are also rich in oily matter, and apparently of as much value as *Calanus* for herring food, yet the herring appears to reject them.

The stomachs examined for this paper number, as already stated, five hundred and twelve. Two hundred and forty-three contained food of a more or less definite kind, while two hundred and sixty-nine were empty or their contents could not be identified. Each of these two groups comprised a nearly equal number of spawners and milters. In the first the females are rather in excess of the males, while in the other the number of males is slightly the greater, but whether food was present or absent, or showed variation in its amount or kind, nothing was observed which could be ascribed to difference in the sex of the fish.

“GUT-POKE” IN HERRING.

The term “gut-poke” in herring has long been familiar to fishermen on the West Coast.

In an interesting paper by the late George Brook, F.L.S., entitled—“A Report on the Herring Fishery of Loch Fyne and Adjacent Districts,”* a short paragraph is devoted to the subject of gut-poke in herring, and it is stated that almost all the herrings in Loch Fyne are liable to the complaint, and that in the month of June the majority of them were in this condition; he also directs attention to the deterioration in the market value of herrings affected by gut-poke.

In the summer of 1894, Dr. Fulton, the Scientific Superintendent of the Fishery Board, desired me to visit Tarbert to make some inquiries into the food of herrings, and suggested that the question—“What is gut-poke in herring?” might receive some attention. Certain inquiries were accordingly made concerning this matter and the results embodied in a short communication to Dr. Fulton, and in the remarks which follow I have incorporated some of the results referred to in that communication. And I would remark, first, that the term “gut-poke” is applied to that condition in herrings when their stomach and intestines are distended with food of a soft and oily nature, such as *Calanus*, post-larval Clupeoids, and the like, the quantity of food in the stomach being so great that it passes into the intestines without being properly digested. When such herrings are captured decomposition rapidly sets in, and they soon become useless and even dangerous as food.

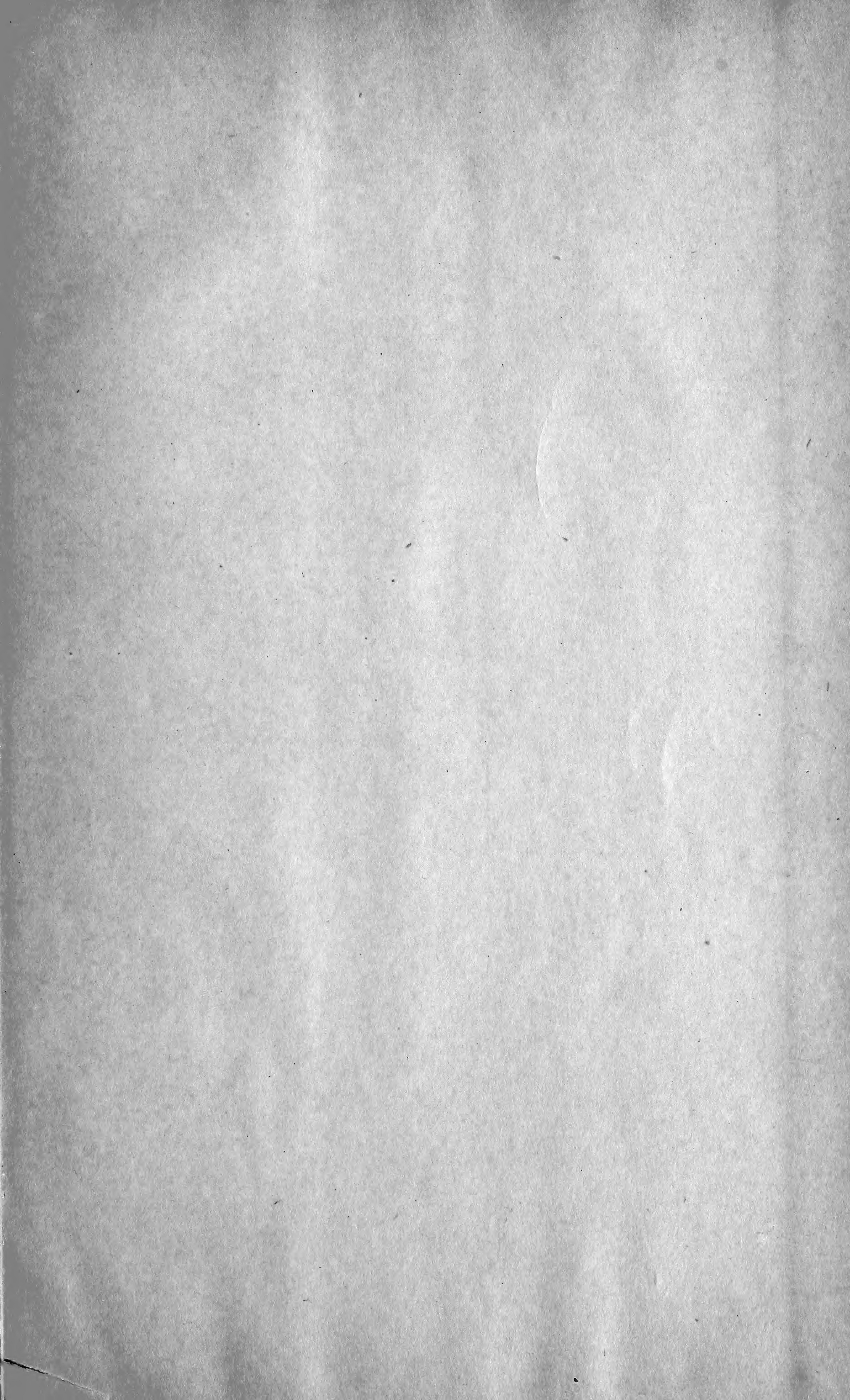
“Gut-poke” is not necessarily limited or peculiar to large or small fishes, but, on the other hand, it seems to be most frequently observed in those with immature reproductive organs. The gut-poke condition is seldom noticed in herrings which are sexually mature or nearly so. But though overfeeding appears to be the immediate cause of gut-poke, herrings are frequently obtained which have a considerable amount of food in their stomach without the gut-poke condition being present.

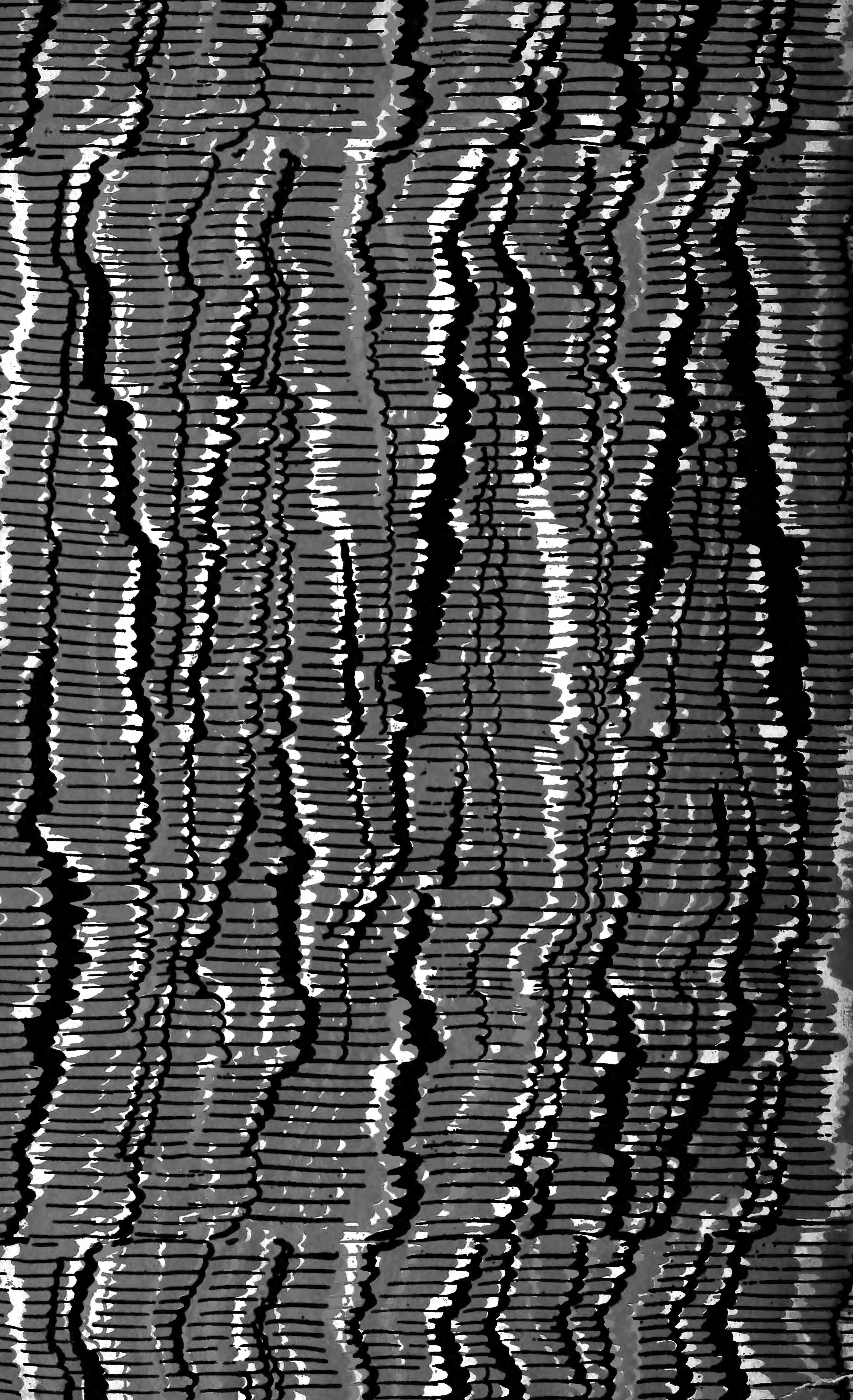
It is doubtful if a really satisfactory explanation can be given about the true cause of gut-poke in herrings, *i.e.*, the reason why at certain times a seemingly abnormal desire for food affects them, and they feed ravenously till the stomach and intestines become gorged, but whatever the cause may be it is apparently only of temporary duration.

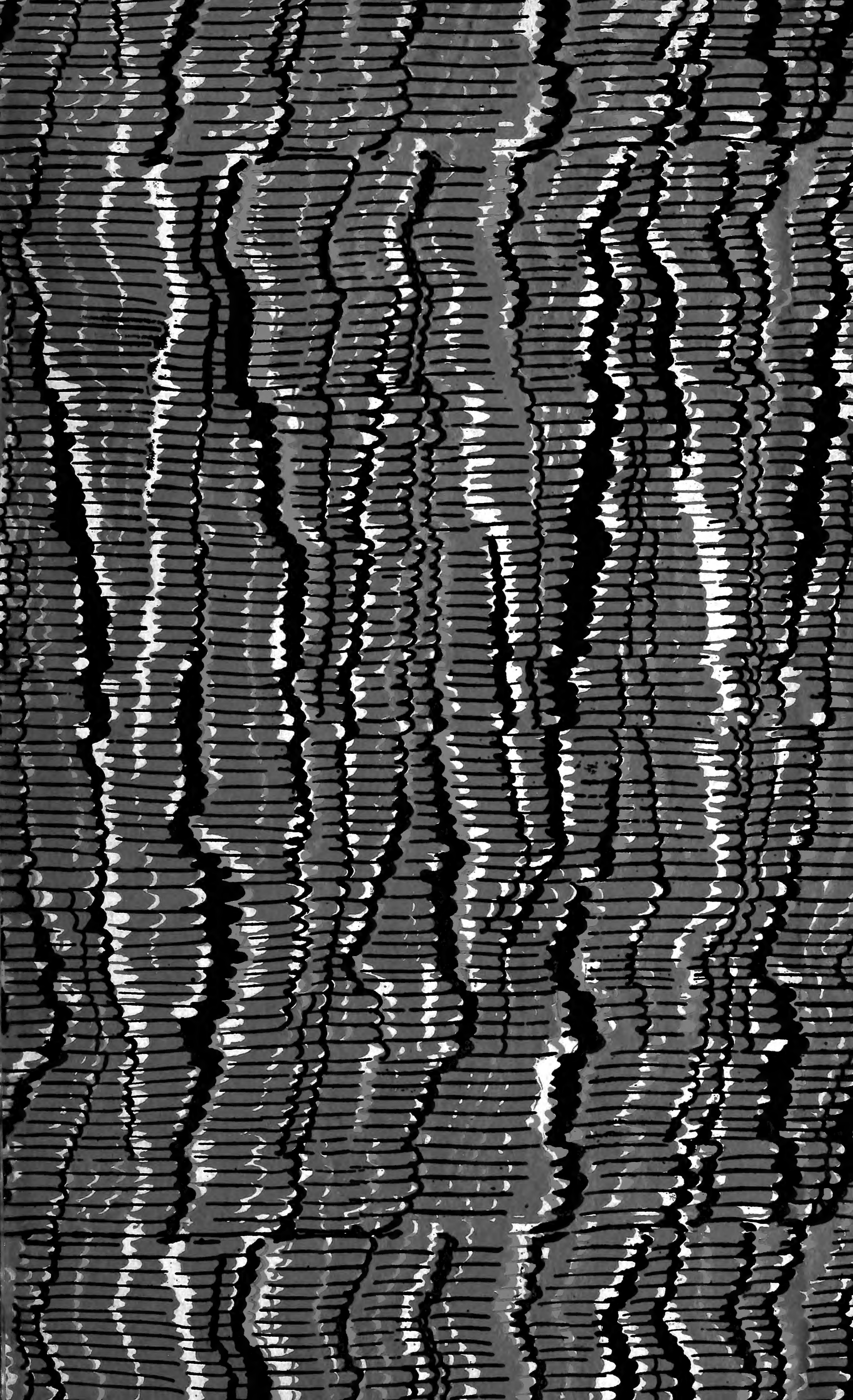
* *Fourth Annual Report of the Fishery Board for Scotland (1886)*, p. 47.

When under the influence of this abnormal craving the fish sometimes approach the surface of the water even during the middle of the day, and have been observed by fishermen greedily feeding on *insects* (probably Copepoda) and young fishes, and this is confirmed by the fact that several of the herrings I examined at Tarbert at the time referred to had their stomachs filled with young herring or sprats about an inch and a half in length. This ravenous desire for food has been ascribed to some disease in the fish, but Mr Brook was inclined to doubt this. Herrings which are finest in quality have usually their stomach and intestines almost empty and their internal organs covered with white healthy fat.

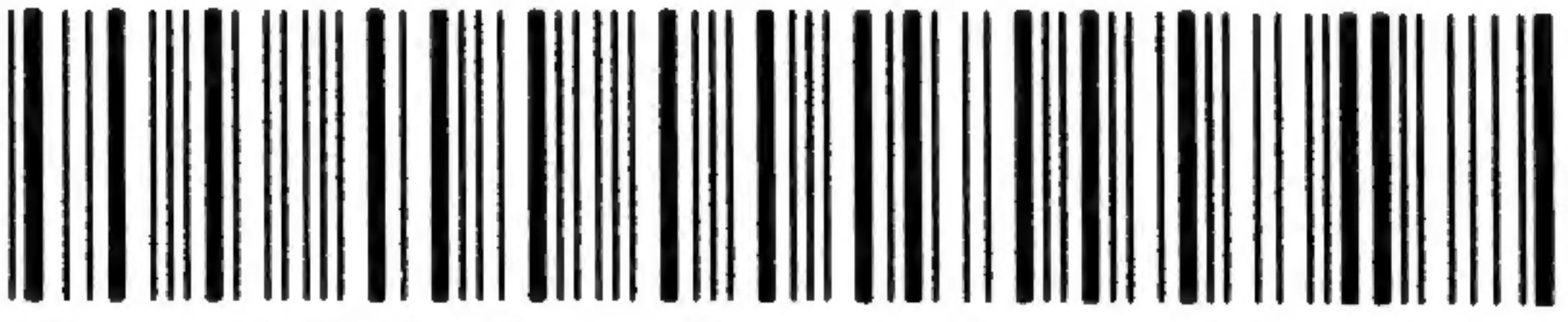








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